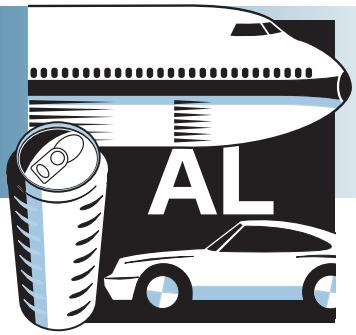
ALUMINUM

Project Fact Sheet



Novel Ceramic Composition for Hall-Heroult Cell Anode Application

Benefits

- Directly addresses aluminum industry's highest priority research need for inert anodes (*Inert Anode Roadmap*, Chapter 3)
- Potential to save more than 90 percent of energy associated with anode production by eliminating carbon-block anodes and reducing anode replacement frequency from several weeks to 1 or more years
- Eliminates oxidation of carbon block that produces the greenhouse gas carbon dioxide ($CO_{2)}$
- Reduces potential for workplace hazards associated with anode replacement in hot operating electrochemical cells
- Reduces amount of energy wasted in heating and cooling a large, thermal-mass carbon anode by reducing anode changes
- Improves cell process efficiency by minimizing and stabilizing anode/cathode gap
- Improves production efficiency by reducing labor associated with anode production and maintenance

Applications

This new technology is applicable primarily in the aluminum smelting industry, where millions of tons of carbon-based anodes are consumed annually in U.S. smelters.

New Ceramic Technology Provides an Inert Anode Material for Aluminum Production

The Hall-Heroult process, the primary means of aluminum smelting worldwide, uses a series of carbon-block anodes in each electrochemical cell. During the smelting process, the electrochemical reduction of aluminum oxide occurs at the anode surface, yielding oxygen. This oxygen then reacts with the carbon, resulting in steady consumption of the anode, as well as the release of large amounts of the greenhouse gas, carbon dioxide (CO_2). The development of a non-reactive or inert anode could significantly improve the efficiency and cleanliness of the process by eliminating the CO_2 by-product and reducing the labor and electrical costs associated with carbon anode fabrication and change-out.

A new ceramic composition has been identified that may prove suitable for application as an inert anode (together with a wettable cathode) in the Hall-Heroult process. This composition is a new type of ceramic material created from a compound including a transition metal, another metal, and an oxidant. Previous evaluation of the material shows it to be electrically conductive, inert to various corrosive salts, and oxidation resistant at 1000°C, all basic criteria for the anode application. Anodes made of this type of non-consumable material would not require frequent replacement, saving downtime, labor, and materials costs.

Aluminum Smelter with Anode Elements

New ceramic anodes have the potential to reduce energy use and greenhouse gas emissions associated with conventional carbon-block anodes in aluminum smelters.

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Project Description

Goal: Evaluate a new type of ceramic material in anode-simulation tests to determine if the material withstands the associated electrochemical conditions.

The materials in this program represent examples of a new type of ceramic, which exhibits properties that fall between metals and ceramics. In addition to suitable electrical conductivity and oxidation and corrosion resistance, researchers have observed that this material is harder than typical metals, but not susceptible to thermal shock.

Using these new ceramic materials in an inert anode application would eliminate the repeated production and installation of carbon-block anodes. Ceramic-based anodes would be expected to require less frequent replacement. This significantly reduced rate of consumption would have a commensurate effect on the costs associated with the current production of carbon-anode blocks, as well as the labor costs associated with the replacement blocks in smelting services.

Advanced Refractory Technologies, Inc., is developing this new technology with the help of a grant funded by the Inventions and Innovation Program in the Department of Energy's Office of Industrial Technologies.

Progress and Milestones

- Prepared billets of two different ceramic materials for anode testing.
- Conducted anode-simulation testing on both sample materials.
- Characterized the sample materials following testing to further evaluate performance.
- Prepare final report on testing and performance, proposing future concept development. Following successful completion of this project, assessment of the technology would be sought on a larger scale in a pilot-scale cell.

Economics and Commercial Potential

The potential for cost, energy, and environmental savings associated with this new technology is substantial. Worldwide, approximately 9 million tons of carbon are consumed and considerable CO_2 is produced each year in the production of aluminum. In the United States alone, approximately 5 million tons of CO_2 are produced annually from the oxidation of carbon-block anodes. The aluminum industry places advanced anode and cathode technology as its highest priority R&D objective for primary production.

At an aluminum smelter with 1,000 pots, about 1,400 replacement carbon-block anodes are required each day. The energy requirement for carbon-block anode production is immense. By contrast, the proposed ceramic anodes would need only infrequent replacement, resulting in energy savings through the reduced need for anode fabrication. Potential for energy savings from decreased anode production frequency is theoretically higher than 25 percent of current use.

If inert ceramic anodes were combined with the ceramic cathode technology and drained cell designs, greater overall energy savings would be expected, with up to 20 percent of smelting energy saved by minimizing and stabilizing the anode/cathode gap.

Industry of the Future—Aluminum

Through OIT's Industries of the Future initiative, the Aluminum Association, Inc., on behalf of the aluminum industry, has partnered with the U.S. Department of Energy (DOE) to spur technological innovations that will reduce energy consumption, pollution, and production costs. In March 1996, the industry outlined its vision for maintaining and building its competitive position in the world market in the document, ***Aluminum Industry: Industry/Government Partnerships for the Future****.*

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The Inventions and Innovation Program works with inventors of energy-related technologies to establish technical performance and conduct early development. Ideas that have significant energy savings impact and market potential are chosen for financial assistance through a competitive solicitation process. Technical guidance and commercialization support are also extended to successful applicants.

Project Partners

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